Galactic Diffuse Gamma Ray Emission >10 GeV

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Abstract. AGILE and GLAST are the next high-energy gamma-ray telescopes to be flown in space. These instruments will have angular resolution about 5 times better than EGRET above 10 GeV and much larger field of view. The on-axis effective area of AGILE will be about half that of EGRET, whereas GLAST will have about 6 times greater effective area than EGRET. The capabilities of ground based very high-energy telescopes are also improving, e.g. Whipple, and new telescopes, e.g. STACEE, CELESTE, and MAGIC are expected to have low-energy thresholds and sensitivities that will overlap the GLAST sensitivity above ~10 GeV. In anticipation of the results from these new telescopes, our current understanding of the galactic diffuse gamma-ray emission, including the matter and cosmic ray distributions is reviewed. The outstanding questions are discussed and the potential of future observations with these new instruments to resolve these questions is examined.

INTRODUCTION

High-energy gamma-ray astronomy has made tremendous progress in the last decade. The results of the Compton Gamma Ray Observatory (CGRO) have revealed an unimagined multitude and wide range of energetic and dynamic sources. Currently about 300 new gamma-ray sources have been discovered, including blazars, supernovae and their remnants, pulsars and black hole candidates, gamma-ray bursts, and hundreds of unidentified sources. In addition, the diffuse gamma-ray emission from the Galaxy, arising from the interaction of cosmic ray electrons and protons with the interstellar medium and low-energy photons, has been used to gain new understanding of the structure, dynamics and evolution of the Galaxy.

The next generation of high-energy gamma-ray telescopes, AGILE [1], and GLAST [2], will have improved sensitivities. However, these telescopes are not expected to be launched until 2002 and 2005 respectively. The capabilities of ground based gamma ray telescopes are also improving. STACEE [3], CELESTE [4], and MAGIC [5], the new generation of ground based telescopes, are expected to have low-energy thresholds and sensitivities that will overlap the GLAST sensitivity in the 10-300 GeV energy range.

In anticipation of the results from these new telescopes, our current understanding of the galactic diffuse gamma-ray emission, including the matter and cosmic ray distributions, is reviewed. The outstanding questions are discussed and the potential for future observations with these new instruments to resolve these questions is examined.

CGRO results and EGRET observations

The *Compton Gamma Ray Observatory* (CGRO) carried four gamma-ray telescopes covering the energy range from 50 keV to 30 GeV. Three of these instruments, OSSE (50 keV–10 MeV), COMPTEL (1–30 MeV), and EGRET (30 MeV–30 GeV), were pointed instruments and BATSE, the forth instrument, was an all sky burst monitor. CGRO was launched in 1991, provided nine years of observations, and was de-orbited in 2000. The OSSE, COMPTEL, and EGRET observations of the Galactic diffuse emission, covering almost 5 decades in energy, are reviewed by Hunter, Kinzer, & Strong [6]. This paper focuses on the EGRET observations of the diffuse emission above 30 MeV, the outstanding questions, and extrapolation of these results to the TeV energy range.

Diffuse Emission Processes

The Galactic diffuse emission has been recognized for some time to arise from the interactions of energetic cosmic-ray (CR) electrons and protons with the interstellar medium via electron bremsstrahlung and decay of π^0 from nucleon-nucleon interactions, and with low-energy photons via inverse Compton emission, Figure 1. Below about 100 MeV, electron bremsstrahlung is the dominant processes, whereas above this energy, nucleon-nucleon interactions is dominant. It is possible, depending on the cosmic-ray electron spectral index, that inverse Compton scattering may be the dominant mechanism above about 100 GeV.

Figure 1. Average diffuse gamma-ray spectrum of the inner Galaxy region, $300° < l < 60°$, $|b| \leq 10°$ (0.73 sr). The contribution from point sources detected with more than 5 σ significance has been removed. The data points are plotted as crosses where the horizontal lines indicate the energy interval and the vertical lines the ± 1 σ statistical errors. The 'best-fit' calculation plus the isotropic diffuse emission is shown as the solid line. The individual components of this calculation, nucleon-nucleon (NN), electron bremsstrahlung (EB), and inverse Compton (IC), are shown as dashed lines. The isotropic diffuse emission (ID, [7]) is shown as a dash-dot line. From [8].
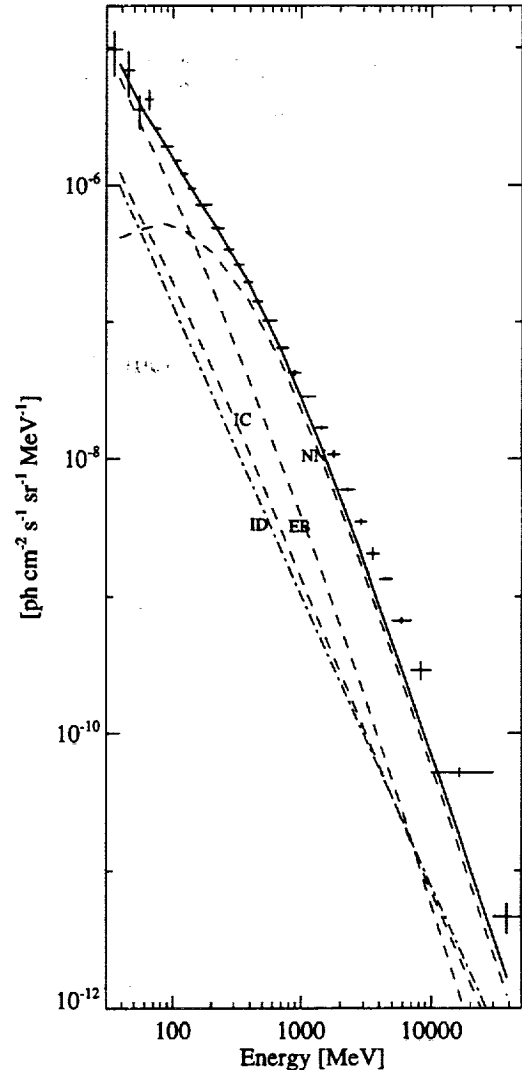
Synchrotron and curvature radiation, the probable dominant gamma-ray production mechanisms in pulsars, are not expected to contribute significantly to the Galactic diffuse emission. The possible contribution from unresolved point sources to the 'GeV excess' is discussed below. The isotropic diffuse emission, now generally

accepted as being extragalactic in origin (possibly an unresolved distribution of gamma-ray blazars), is assumed here to be isotropic and to have a simple power-law spectrum [7].

Models of the Diffuse Emission Model

Because the galaxy is essentially transparent to high-energy gamma rays, the diffuse gamma-ray emission traces the line-of-sight integral of the product of the matter density and cosmic ray density. Radio observations are used to determine the structure and density of the interstellar medium (ISM), which consists primarily of atomic, molecular, and, to a lesser extent, ionized hydrogen. Helium and heavier elements represent about 10% and 1% of the hydrogen number density, respectively. The atomic hydrogen column density is directly observable in terms of the 21 cm emission [9], whereas, the molecular hydrogen column density is inferred from the 115 GHz emission of CO [10]. In addition, the Doppler-shift of this emission due to the differential Galactic rotation can be used to interpret these observations in terms of the large-scale structure of the Galaxy. The Galactic rotation is usually assumed to be everywhere circular and the angular velocity is a function only of the Galactic radius.

The Galactic distribution of cosmic-ray electrons and protons is less well known, having been measured only in the Solar vicinity. The local proton spectrum is considered to be representative of the spectrum throughout the Galaxy. Electrons, on the other hand, lose energy rapidly via synchrotron, bremsstrahlung, and inverse Compton scattering and diffuse only a short distance from their source [11]. Thus, the local electron spectrum may not be representative of the spectrum throughout the Galaxy. A model of the diffuse gamma-ray emission can thus be used to test assumptions about the distribution and propagation of cosmic rays in the galaxy.

Different approaches have been used to model the diffuse emission and to compare with the EGRET data. These approaches, which are based on different assumptions, can be described as the '*parametric model*', the '*dynamic balance model*', and, more recently, the '*cosmic ray injection and propagation model*'. All three of these approaches use similar low-energy photon distributions and kinematic deconvolutions of the HI and CO radio data to determine the interstellar matter density, but differ in the techniques and assumptions used to model the comic ray density.

The '*parametric model*' [12] is a method based on the assumption of a cylindrically symmetric distribution of the gamma-ray emissivity. The galaxy is divided into six rings, 2-4 kpc in width. The free parameters of the model for each energy range are the gamma-ray emissivity per H-atom per CR proton in the six rings, the $N(H_2)/W_{CO}$ mass conversion factor, a scaling factor for the 1-3 MeV inverse Compton intensity, the flux of the 12 brightest point sources, a scaling factor for the remaining sources in the 2nd EGRET catalog not included explicitly, and the isotropic diffuse emission. The value of these parameters was determined by fitting the model to the Phase 1+2 EGRET data for the region averaged over the region $10° < l < 350°$, $|b| < 60°$.

The '*dynamic balance model*' [8,13] is a three-dimensional calculation based on the galactic nature of cosmic rays [7] and the assumption of dynamic balance. Dynamic balance, which refers to the balance between the overall gravitational attraction of the interstellar matter and the expansive pressures in our Galaxy from the cosmic-rays, interstellar matter, and magnetic fields [14,15,16], implies a higher cosmic ray density

where the matter density is higher. Only a few other assumptions were made in this model. 1) Synchrotron emission as well as the contribution from unresolved sources is insignificant; i.e. all the observed 'diffuse' emission is from cosmic rays interacting with the ISM. 2) The spectral indices of the cosmic ray electron and proton spectra throughout the galaxy are the same as the local spectra corrected for solar modulation. 3) The cosmic ray electron to proton ratio is constant throughout the Galaxy. 4) The cosmic ray scale height is also constant and independent of Galactic radius. These assumptions lead to only two free parameters in the model. The molecular mass calibrating ratio, $N(H_2)/W_{CO}$, and the coupling scale of cosmic rays to the matter, r_0. The other astrophysical parameters used are fairly well determined. These two parameters were determined by fitting the model to the EGRET data. The 'best-fit' model accurately predicts the diffuse emission on $1°$ spatial scales, typically within $\pm 1 \sigma$, Figure 2, as well as the spectrum from 30 MeV up to ~1 GeV, Figure 1 and Figure 3. There are, however, three discrepancies between the predicted diffuse emission and the EGRET observations, discussed below, that are significant because they are correlated over large angular scales.
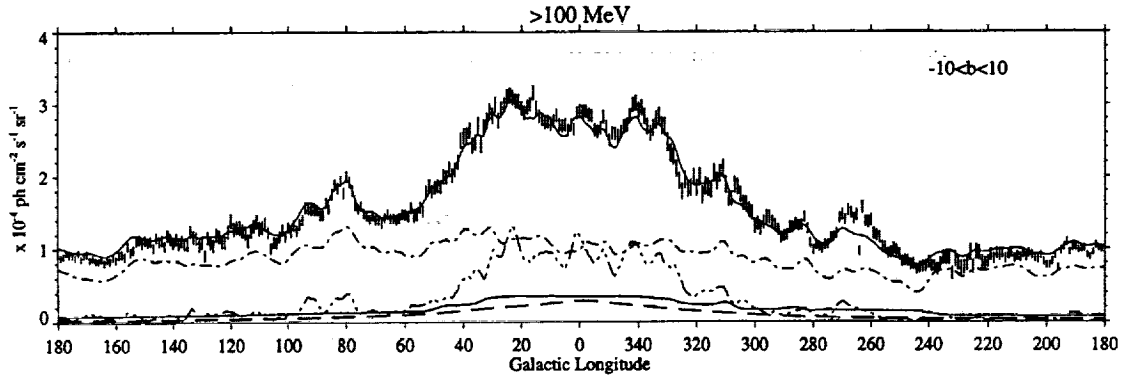

Figure 2. The diffuse gamma ray intensity, E > 100 MeV, measured by EGRET as a function of Galactic longitude compared to the model of Hunter et al. ([8], solid line through data). The vertical lines are $\pm 1 \sigma$ intensity averaged over $1°$ longitude intervals and summed over the interval $|b| \leq 10°$) The lower lines represent the contribution from cosmic rays interacting with atomic hydrogen (dash-dot line), molecular hydrogen (dash-triple dot line), ionized hydrogen (solid line), and the inverse Compton radiation (long dashed line).

The 'cosmic ray propagation model' [17] is a cylindrically symmetric, numerical method developed for the calculation of Galactic cosmic-ray propagation. Primary and secondary nuclei and electrons, secondary electrons, positrons, and antiprotons as well as gamma ray and synchrotron radiation are included. The propagation mechanisms included are diffusion, convection, energy loss, fragmentation, and diffusive reacceleration. The 10 MHz –10 GHz synchrotron emission and spectral index is used to constrain the interstellar electron spectrum and the Galactic magnetic field model. The distribution of cosmic-ray sources is chosen to reproduce the cosmic-ray distribution determined with the parameter model [12]. The injected electron and proton spectra are assumed to be power laws, possibly with a spectral break. Strong, Moskalenko, and Reimer [18] examined a range of cosmic ray spectra which they compared with the EGRET data to examine alternative explanations for the GeV excess. Their best-fit model is discussed below.

Each of these three approaches has distinct advantages. The *parameter model* readily allows for studying both the energy and radial dependence of included parameters. Strong and Mattox [19] concluded that an energy dependent molecular mass calibrating ratio is not required to fit the EGRET data, although the large error bars do not rule out such dependence. The *dynamic balance model* is a direct calculation that allows for straightforward interpretation of the discrepancies between the model and the observations. This advantage is utilized below; the outstanding questions related to the diffuse emission are interpreted in terms of the assumptions of this model. The *cosmic ray propagation model* allows for testing of various cosmic-ray proton and electron spectra constrained by a wide range of other observations.
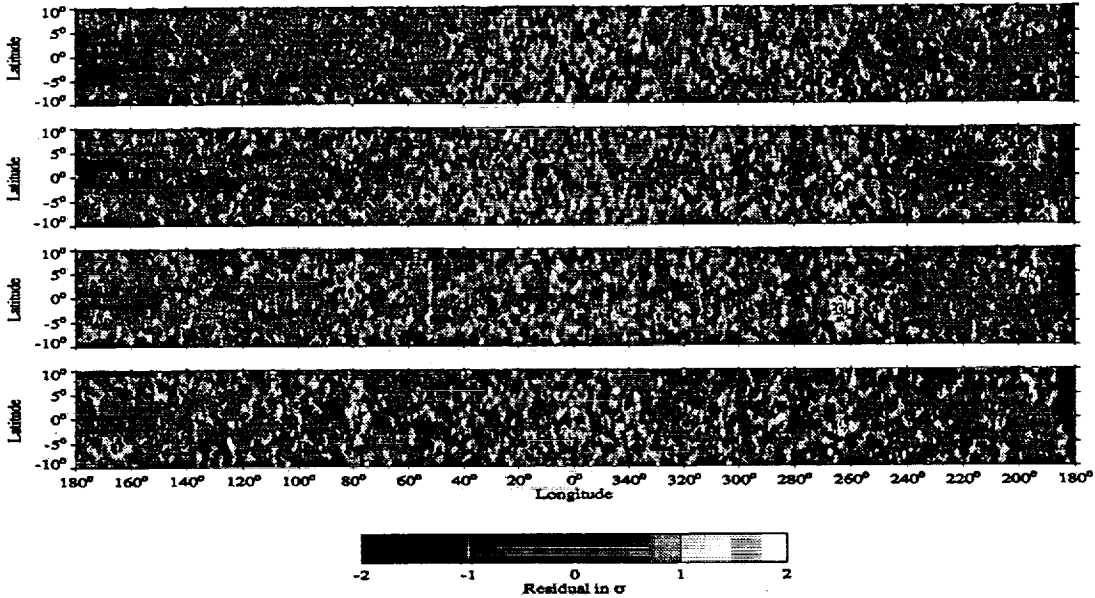

Figure 3. Residual intensity obtained by subtracting the best-fit model plus the isotropic diffuse emission from the observed diffuse emission for (a) 30 < E < 100MeV, (b) 100 < E < 300MeV, (c) 300 < E < 1000MeV, (d) E > 1000MeV expressed in terms of statistical uncertainty on the observation. The model for E > 1000 MeV has been scaled by 1.6 to correct for the spectral discrepancy between the observation and the model.

The Cosmic Ray Distribution

The cosmic ray density in the Galactic plane, derived on the assumption of dynamic balance and smoothed on the spatial scale of the coupling parameter, $r_0 \approx 2.4$ kpc, is shown in Figure 4a. The cosmic ray radial density is compared in Figure 4b with the density determined by Strong et al. [12] using the parametric model described above. The cosmic ray density determined by both models is generally peaked towards the Galactic center and decreases fairly smoothly, except for an enhancement in quadrants II and III beyond the Solar circle, to near zero at a radius of about 25 kpc. The density derived by Strong et al. tends to be slightly less peaked towards the Galactic center and does not show the enhancement at about 15 kpc.

Figure 4. (*a*) The Galactic cosmic ray density relative to the
local Solar density, $c = 1.0$, derived on the assumption of
dynamic balance. (*b*) The azimuthal average cosmic ray
density for each Galactocentric quadrant indicated in (*a*).
The radial average density determined by Strong et al. ([12],
150-300 MeV, case 3, scaled to $R_o=8.5$ kpc, and normalized)
is indicated by the dotted line. From [8].

What We Have Learned from EGRET

The EGRET observations have confirmed the
galactic nature of cosmic rays [7], and the existence
of a "π^0 bump" in the diffuse spectrum, Figure 1
[8,19]. The lack of spectrum variation of the diffuse
emission, in the range 30-100 MeV [8], is an
indication that the electron to proton ratio is fairly
uniform over the Galaxy, at least on the scale of the
coupling parameter. On a similar scale there does not
appear to be any variation of the cosmic ray electron
or proton densities between the Galactic arm and
interarm regions. The visibility of the "pion-bump"
constrains the contribution from an unresolved
distribution of power-law sources. The accurate
reproduction of the structure of the diffuse emission,
both in latitude and longitude, Figure 3, supports the
assumption of dynamic balance.
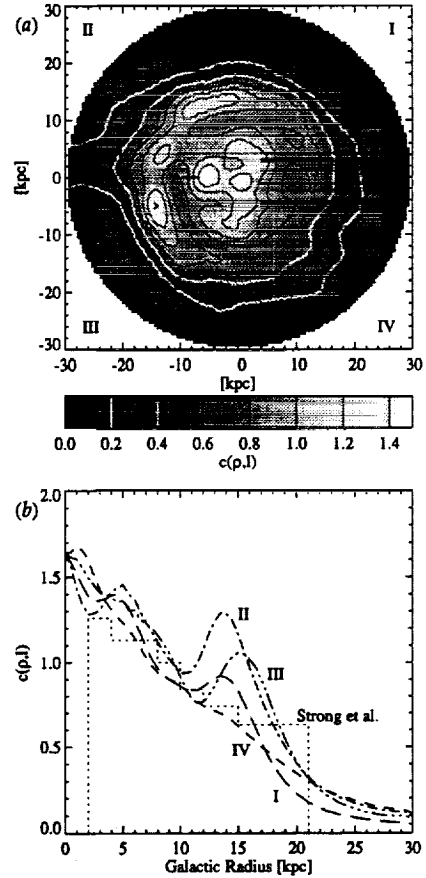
THE OUTSTANDING QUESTIONS

There are three major discrepancies between the predictions of the above models
and the EGRET observations: 1) the spectral excess above ~1 GeV, 2) the under-
prediction at medium latitudes toward the Galactic center, and 3) the over-prediction
in the outer Galaxy. We discuss these separately and interpret their significance.

The GeV Excess

Both the parameter model and the dynamic balance model, which are based on
derived production functions and the local measured cosmic ray spectra corrected for
Solar modulation, under-predict the diffuse flux above 1 GeV [20], Figure 1. The
ratio of the observation to dynamic balance model is shown in Figure 5. The excess
above ~0.4 GeV can be well fitted with a power law with spectral index of 0.29±0.04.

Mori [21] and Chang et al. [22] have examined two possible explanations for the
GeV excess using hadronic Monte Carlo codes. These possibilities are 1) the Galactic
average cosmic-ray proton spectrum may be softer than observed locally, and 2) the
interaction models of π^0 production may not adequately include the several other
resonances, mesons, and hadrons, which also decay and produce gamma rays at high
energies. Mori found that a softer proton spectrum $\left(\propto E_p^{-2.45} \right)$ provided the "best-fit"
to the EGRET Galactic center spectrum. Chang et al. concluded from a derivation of

the gamma-ray yield for nuclear interactions directly from the Monte Carlo models, Figure 6, that the EGRET Galactic center spectrum could be explained using the local demodulated proton spectrum determined by Webber and Potgeiter [23].

Figure 5. Ratio of the observed Galactic center diffuse emission to the predicted flux (see Figure 1) versus energy. The solid line is a power-law fit to the excess. The difference is the spectral index is 0.29±0.04.

Strong, Moskalenko, and Reimer [18] have suggested another explanation. Their hard electron and broken nucleon spectrum (HEMN) model, optimized to match the high-energy gamma rays, suggests that inverse Compton emission dominates over the π^0 decay below ~100 MeV and above ~3 GeV, Figure 7a. They further conclude that the bremsstrahlung emission is insignificant, not more than ~10% of the Galactic emission at any energy. Although this model agrees with the EGRET data at 10 GeV and is consistent with the antiproton and positron observations, the medium-energy (E < 30 MeV) emission is significantly under-predicted. The missing flux below 30 MeV is attributed to an unresolved distribution of point sources.

Figure 6. Diffuse spectrum from the Galactic center region (300° < l < 60°, |b| ≤ 10°) multiplied by E2 for different CR proton spectra. The thick solid line is the demodulated proton spectrum determined by Webber and Potgeiter [23]. From [22].

A third explanation is that the GeV excess is due to unresolved point sources, such as pulsars [24]. There are two difficulties with this explanation. First the GeV excess emission is well correlated with the total ISM, a single scaling factor 'corrects' the model emission to agree spatially with the observation, Figure 3. Thus, the unresolved point sources must be distributed like the total, atomic plus molecular components of the ISM. Second, the average spectrum of the unresolved sources must have a strong spectral break at ~1 GeV, similar to the unique broken power-law spectrum of PSR 1706-44 [25], to avoid exceeding the observed low-energy flux, and Figure 8.
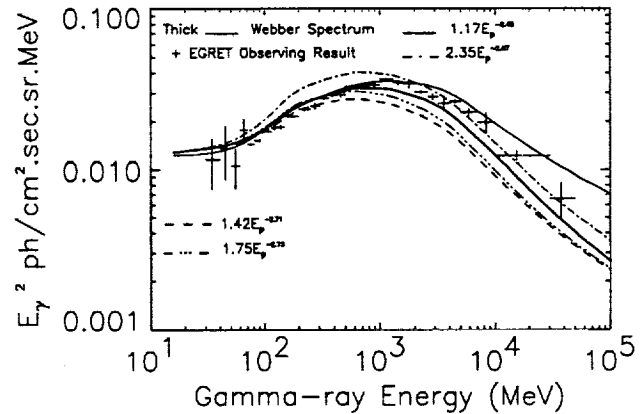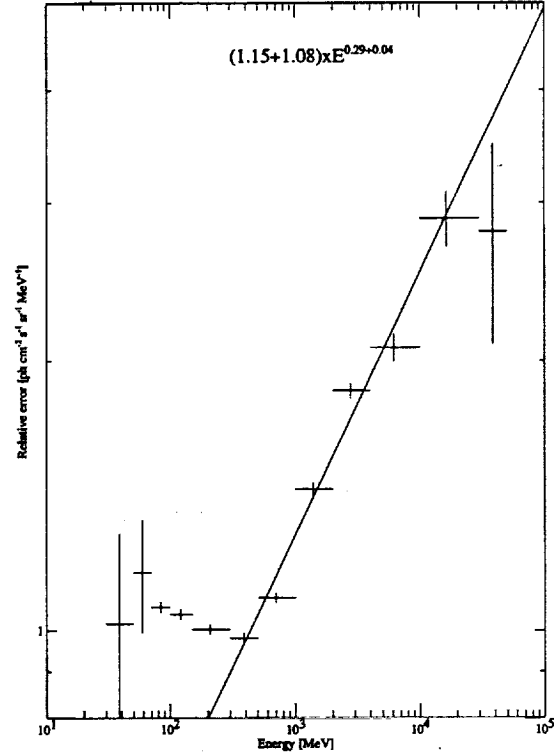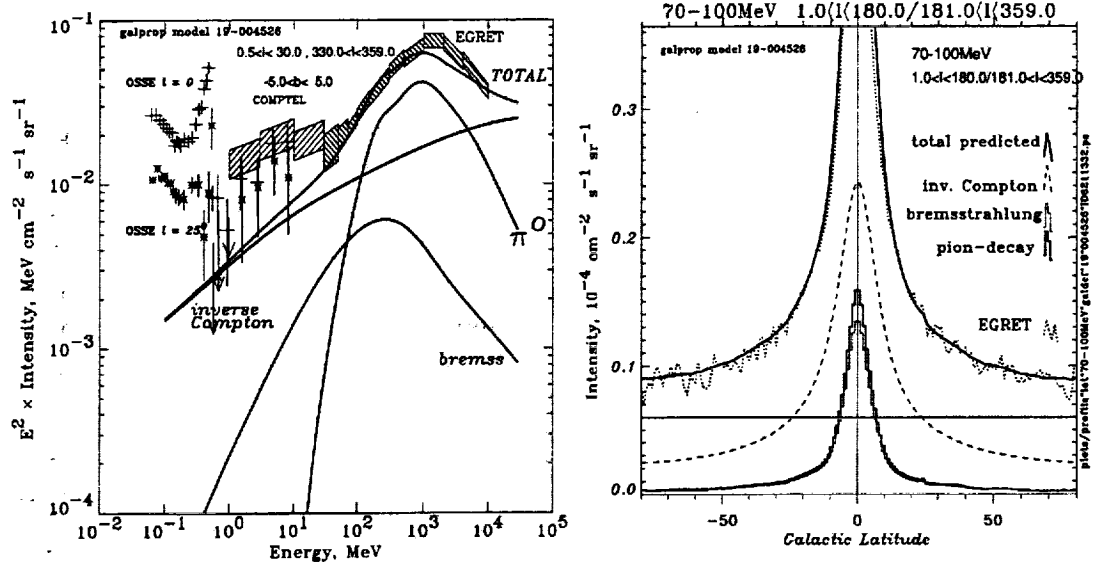
Figure 7. (a) Gamma-ray energy spectrum of the inner Galaxy (300° ≤ l ≤ 30°, |b| ≤ 5°) compared with the HEMN model (electron injection index −1.8, and modified nucleon spectrum). (b) High latitude distribution of 70-100 MeV gamma rays from EGRET compared to the HEMN model (thick solid line). Separate components show the contribution from IC (dashed line), bremsstrahlung (thin histogram), π^0 decay (thick histogram), and isotropic background (horizontal line) From [18], Figs. 13 and 16.

Under Prediction at Medium Latitudes towards the Galactic Center

Extended diffuse emission, extending to about ±30° in latitude, is visible towards the Galactic center. This emission is most likely inverse Compton emission that is not accounted for in the diffuse models. The standard EGRET diffuse model used to produce the EGRET catalogs is a combination of the low-latitude (|b| ≤ 10°) dynamic balance model [8] and the high latitude (|b| > 10°) model [7] used to determine the isotropic emission. The high latitude model included only the 'local' emission (r ≤ 1 kpc) at latitudes above 10° and, hence, any medium latitude emission from the Galactic center was excluded *a priori* from the standard EGRET model.

New calculations of the interstellar radiation field (ISRF) [18, 26] based on the COBE data coupled with an increased cosmic ray electron scale height are likely to correctly model this extended emission. For example, Strong, Moskalenko, & Reimer [18] investigated large CR electron scale heights with their HEMN model. This model, with the $N_{particle}$ = 0 boundary at z_h = 4-10 kpc, accurately predicts the emission in the latitude range |b| > ~15°, Figure 7b, although the lower latitude emission is slightly over predicted.

Over Prediction in the Outer Galaxy

The dynamic balance model over-predicts the diffuse emission in the outer Galaxy (~90° < l < ~270°), Figure 2. Although this over-prediction is less than ~10%, it is fairly well correlated over this entire longitude range. This discrepancy may be an indication that the assumption of dynamic balance breaks down in the outer Galaxy

where there are fewer CR sources. The HEMN diffusion model [18] (see e.g. Fig. 15) also tends to over-predict the outer Galaxy; however, this model was optimized to agree with the diffuse spectrum rather than the longitudinal distribution.

MEASUREMENTS ABOVE 100 GeV

High-energy gamma rays observed with unpointed, balloon-born emulsion experiments [27,28] and the present observations of the diffuse emission from the Galactic disk ($35° < l < 40°$, $|b| \leq 2°$) by Whipple [29], Figure 8, provide important upper limits to the Galactic diffuse emission above 50 GeV. These results are consistent with an extrapolation of the deconvolved EGRET spectrum (see [8], Fig. 5b). Assuming there is no break in the diffuse spectrum, these upper limits constrain the spectral index of the diffuse emission to be ≥ 2.4. This constraint is inconsistent with the HEMN model of Strong, Moskalenko, & Reimer [18], Figure 7a, since the spectral index of the dominant inverse Compton component is ~2.1 at 10 GeV.

Figure 8. Measurement of the Galactic diffuse emission > 50 GeV with the Whipple telescope [29] extrapolated to the EGRET energy range on the assumption of single power-law spectral indices of 2.0, 2.2, 2.4, and 2.6. The spectral index must be ≤ 2.4
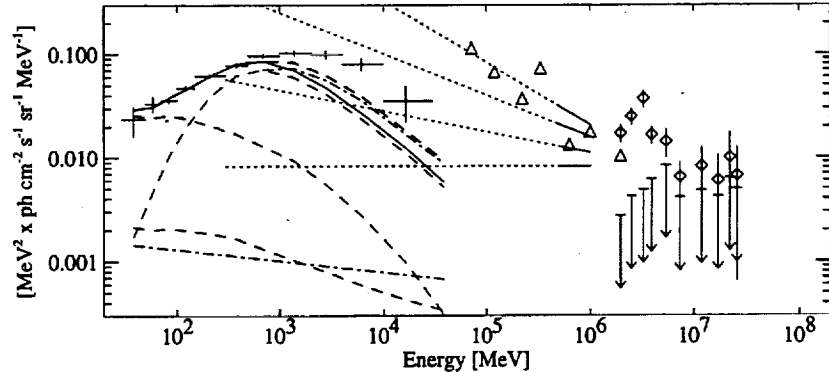
to be consistent with the EGRET observations, shown as ±1 σ data points. The unpointed balloon results from Nishimura et al. [28] and the JACEE experiment [27], taken at 4 gm/cm^2 and 5.5 gm/cm^2, shown as triangles and diamonds, respectively, should be treated as upper limits. The JACEE results corrected for the atmospheric contribution are shown as upper limits.

FUTURE GAMMA-RAY TELESCOPES

GLAST (Gamma-ray Large Area Telescope) [2] and AGILE (Astro-rivelatore Gamma a Immagini LEggero) [1] will be the next high-energy gamma-ray missions to be launched, in 2005 and 2002 respectively. The high-energy capabilities of these instruments are summarized in TABLE 1.

Substantial improvements in the sensitivity and angular resolution of ground based, air Cherenkov telescopes have been made. Of these new instruments, STACEE [3] and CELESTE [4], which have recently begun operation, and MAGIC [5],

TABLE 1. Future Space Gamma-ray Telescopes

GLAST	(2005 launch)	wrt EGRET
Angular resolution	0.1° - 0.2° at 10 GeV	~6 × better
Field of view	2.4 sr	~3 × better
Eff. area (front det.)	5×10^3 cm^2, E > 1 GeV	~6 × better
Energy resolution	< 0.12 σ_E/E, E > 10 GeV	~2 × better
AGILE	(2002 launch)	
Angular resolution	Similar to GLAST	
Field of view	Similar to GLAST	
Effective area	Similar to EGRET	
Energy resolution	Limited above ~500 MeV	

which is expected to begin operation next year, are well suited to observations of the diffuse emission. The capabilities of these telescopes are summarized in TABLE 2.

The sensitivities of these new instruments will overlap in the 10–300 GeV energy range, Figure 9. Simultaneous observations will allow accurate calibrations of ground-based instruments.

The longitude selected by the Whipple group (l = 45°) is a good choice for telescopes located in the Northern Hemisphere. The diffuse emission is ~1/2 of the Galactic center emission and there are relatively few EGRET point sources, which might contaminate the measurements. The spectrum of the diffuse emission at l = 45°, measured with EGRET, Figure 8, and an extrapolation of this spectrum in Figure 9.

TABLE 2. Future Air Cherenkov Telescopes

STACEE/CELESTE	(operating)
Angular resolution	~0.2°
Field of view	0.5°
Energy resolution	~30%, E > 50 GeV
Detection threshold	~0.1 crab
MAGIC	**(2001)**
Angular resolution	~0.2°
Field of view	~4°
Energy resolution	~50% at 10 GeV ~20% at 100 GeV ~10% at 1 TeV

Figure 9. Point source sensitivity of new space and ground based gamma-ray instruments. The sensitivities of GLAST and STACEE/CELESTE, MAGIC, and VERITAS overlap in the unexplored 10 – 300 GeV energy range [30]. The spectrum of the diffuse emission from a 2 ×2° deg bin, centered on l ≈ 45°, b = 0°, extrapolated from the EGRET observations, is shown as a solid line. The extrapolated spectrum has a spectral index of ~1.4.
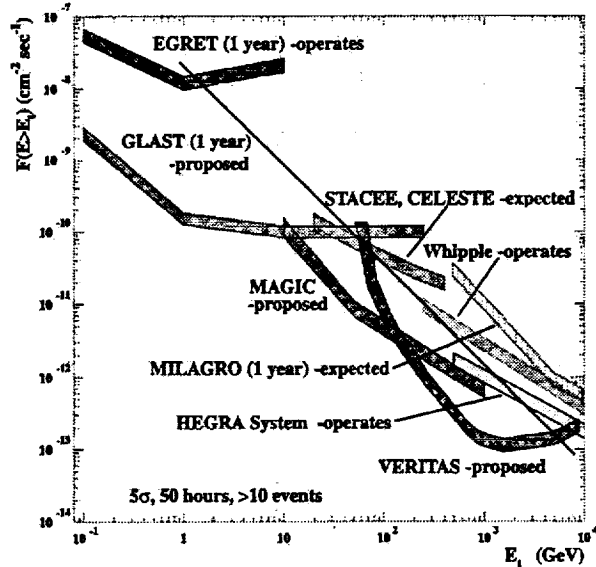
What will GLAST Tell Us?

Observations with GLAST of the diffuse emission will be used to address the outstanding questions discussed above. In particular GLAST will be able to study the GeV excess, spectral variation, and resolve structure in the diffuse emission.

Determination of the diffuse emission spectrum and spectral variation is a trade-off between angular resolution (bin size) and width of the energy interval (statistics). Spatially resolved spectral analysis of the EGRET data was done using 40 deg^2 bins (10° × 4°) with 10-40% statistical errors and highest energy interval of 10-30 GeV. The Galactic center spectrum, Figure 1, was extended up to 50 GeV by averaging over a 240 deg^2 bin. GLAST, with its larger effective area (5×10^3 cm^2) and 1 year of scanning mode operation, will permit spectra to be derived for smaller area bins and to somewhat higher upper energies. If ≤30% statistical uncertainty is required in the

highest energy bin, corresponding to ~10 photons, then it should be possible to derive spectra for 4 deg^2 bins up to ~80 GeV towards the Galactic center and ~15 GeV in the anti-center, Figure 10. Spectra can be derived up to higher energies by averaging over larger bins as was done with the EGRET data.

Figure 10. The study of spectral variation of diffuse emission is a trade off between angular resolution (bin size) and number of photons in the highest energy bin (statistics). GLAST is expected to produce spectra of the diffuse emission up to ~15 GeV toward the anti-center, and up to ~80 GeV toward the Galactic center for 4 deg^2 bins with better than ~30% statistical uncertainty in the highest energy bin.
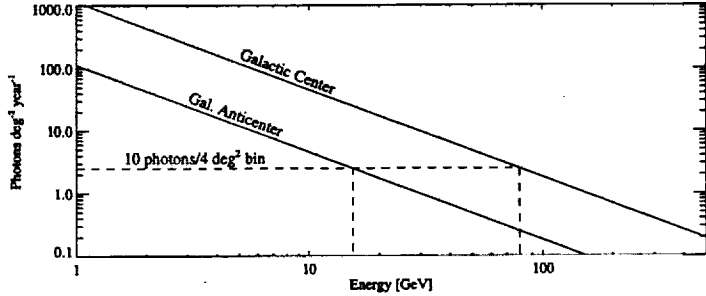
The ability of GLAST to spatially resolve the diffuse emission can be defined (somewhat arbitrarily) as the minimum pixel size such that there are ~10 photons per pixel, after an energy selection (e.g. all photons with E > 1 GeV) is made such that 68% of the photons fall in the pixel. Given this definition, GLAST should be able to image the diffuse emission toward the Galactic center (anti-center) with pixels of about 0.2° (0.3°) in diameter with E > 2 GeV (1.3 GeV) gamma rays.

Figure 11. The ability of GLAST to resolve extended emission or to image the diffuse emission is a function of the required statistical accuracy, the energy cut (i.e. $E_\gamma \geq E_{cut}$), and the surface brightness of the emission. After 1 year of GLAST scanning mode operation ($A_{eff} = 5 \times 10^3$ cm^2), it should be possible to image the diffuse emission on a scale of ~0.3°, with ≥ 10 photons, $E_\gamma \geq 1.3$ GeV, per pixel.
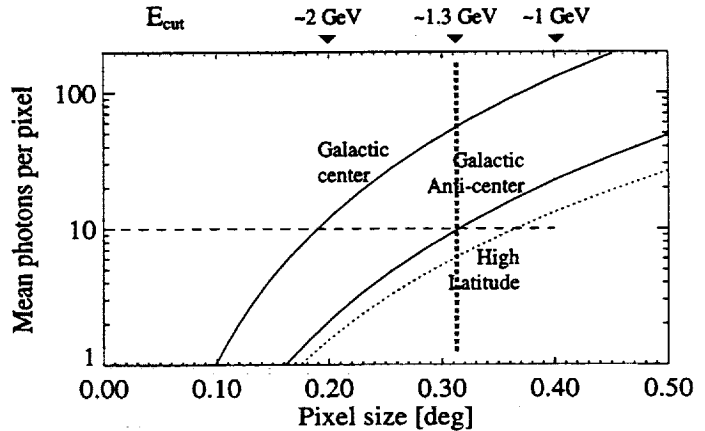
GROUND BASED OBSERVATIONS

The upper limit on the diffuse emission from WHIPPLE is a tantalizing result. The sensitivity of WHIPPLE, Figure 9, is almost sufficient to detect the diffuse emission above 500 GeV at $l = 45°$. The sensitivity of STACEE and CELESTE may be sufficient for these telescopes to measure the spectrum of the diffuse emission in the 20-80 GeV energy range. In addition, the small, ~0.5°, field-of-view of these telescopes will permit imaging with better spatial resolution than GLAST at these energies; however, spectral variation studies on large angular scales are unlikely because of time constraints. MAGIC is expected to have significantly better sensitivity and should be able to measure the diffuse emission spectrum from ~10 GeV to ≥ 100 GeV. The 4° field-of-view of MAGIC is well matched to studies of spectral variation.

CONCLUSIONS

GLAST will measure the spectrum of the Galactic diffuse emission up to ~80 GeV toward the Galactic center, ~15 GeV toward the anti-center, and be able to study spectral variations on an angular scale of ~4°. GLAST will image the diffuse emission on spatial scales of ~ 0.3° in gamma rays of energy >1.3 GeV. Observations of the diffuse emission with STACEE and CELEST will extend the spectra up to ~100 GeV. The ~0.5° field-of-view may limit the extent of spectral variation studies that will be possible. MAGIC will extend the measured spectrum of the diffuse emission up to ~1 TeV. The angular resolution and larger field-of-view of MAGIC will enable large area studies of the diffuse emission with spatial resolution comparable to GLAST, but at 10 GeV-1 TeV energies. Observations of the diffuse emission made with these new gamma-ray telescopes will confirm the existence of the GeV excess and address the questions of spectral variations, CR electron to proton ratio, and CR acceleration and propagation.

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